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7.0 ECOLOGICAL EVALUATION

The Area I study area ecological evaluation is based on the ecological risk assessment (ERA) performed by the National Oceanic and Atmospheric Administration (NOAA, 1998) and additional ecological analyses conducted by SAIC (SAIC, 1998 and 1999). The purpose of this ecological evaluation is focus on an evaluation of the risks to ecological receptors from Raymark soil-wastes/fill within the Area I study area.

The NOAA ERA was performed to identify the risks to ecological receptors from Raymark-type contaminants associated with Ferry Creek and the Housatonic River. NOAAs analysis was limited to aquatic environments in the "upper reaches of Ferry Creek", "lower reaches of Ferry Creek", the Housatonic River at the mouth of Ferry Creek, and the wetland area south of the Housatonic Boat Club. These three areas overlap with Areas A-1, A-3, B, and C. This evaluation focuses on the Area I study area, specifically Area A-1 and A-3 (Area A-2 has no ecological receptors). Subsequent reports will address the remaining areas.

The ERA focused on aquatic pathways and receptors; the primary ecological receptors considered were aquatic biota and avian species that are linked to the aquatic habitat through the food chain. The ERA was updated by the addition of a food chain analysis that included a mammalian receptor that feeds on aquatic biota such as fish, crustaceans, and insects (SAIC, 1999). The update also included additional exposure parameters for birds. See Appendix D for presentation of the entire ERA, including a glossary of terms used in this section. SAICs food chain analysis is also in Appendix D.

7.1 Site Description and Potential Receptors

This section presents the characteristics of the Area I study area that are relevant to the Ecological Evaluation, and identifies the ecological receptors that are potentially exposed to contaminants in the environmental media at the site. A brief discussion of the nature and extent of contamination in the study area is included, however, a comprehensive nature and extent discussion is presented in Section 4.0.

7.1.1 Study Area Description

The Area I study area is a former marsh, part of what was once an extensive salt meadow marsh bordering the Housatonic River (B&RE, 1998). Area A-2 was filled; this filling displaced the channel of Ferry Creek and moved it to its present location. No ecological receptors remain in Area A-2. Ferry Creek has been channelized, there is some rip-rap on its banks in Area A-1, and its banks are steep and topped by a berm of fill material in Area A-3. The channel is armored where it passes under Ferry Boulevard. *Phragmites australis* (a reed that is typically associated with physical or hydrological disturbances in tidal marshes) dominates what remains of the marshland in Areas A-1 and A-3. The upland vegetation along Ferry Creek in Area A-1 is comprised of small trees, shrubs, and coarse herbs. The upland vegetation in Area A-3 is similar to A-1 except trees are less dominant and some areas are mowed grasses.

7.1.2 Water and Sediment Quality

Long Brook joins Ferry Creek just north of Area A-1 near Interstate 95 and the Amtrak line (see Figure 1-1), approximately 300 meters upstream of the former Raymark Facility Lagoon No. 4 discharge to Ferry Creek (HNUS, 1995). All of Ferry Creek is tidally influenced within the study area. There are indications that tidal flow extends up Ferry Creek to Long Brook (near the Stratford shopping center). At low tide, Ferry Creek becomes very shallow, fed only by freshwater flow from Long Brook and from groundwater seepages. Salinity measurements in Ferry Creek have been measured as high as 18 parts per thousand (ppt); this measurement is similar to measurements in the Housatonic River (NOAA, 1998). The average salinity of sea water is 35 ppt.

Dissolved oxygen measurements in Ferry Creek range from 4.2 to 8.2 mg/L, taken at temperatures of 24.1 and 26.7 degrees C, respectively (NOAA, 1998). The 4.2 mg/L value was about 55 percent of the concentration expected when water is saturated with dissolved oxygen, while the 8.2 mg/L value indicated saturation. The range for pH measurements was 5.5 to 7.93. These values are typical for salt marshes receiving fresh water input.

Three measurements were taken for evaluating sediments: grain size, total organic carbon (TOC) content, and the concentrations of acid-volatile sulfides and simultaneously extracted metals (SEM-AVS). Sediment grain size is related to water velocity; as velocity decreases, smaller particles settle out. Therefore, grain size indicates whether samples are from an area where fine particles (clays and silts) have settled. Many contaminants adhere to particle surfaces, so fine particles are likely to contain more contaminants per unit of mass. In general, depositional areas are sediments with more than 50 percent fines. The range of grain size data for background locations was 50 to 100 percent fines (NOAA, 1998). In Areas A-1 and A-3, the range was about 10 to 100 percent fines, with a median value of approximately 35 percent fines.

Organic compounds tend to adhere to organic matter on particle surfaces. TOC measurements are used to estimate how much of a compound may be adsorbed to the sediment. In general, higher TOC measurements indicate higher adsorption potential. Dissolved organics are considered more available to exposed organisms than adsorbed contaminants. Median values for TOC were 1.7, 5.0, and 4.4 percent for Areas A-1, A-3, and the background locations, respectively (Table 7-1). TOC results in Area A-3 ranged from approximately one to 100 percent. In general, the TOC values do not indicate that the Area I study area sediments are unusual in the availability of contaminants.

SEM-AVS is related to the availability of bivalent metals in sediment pore water. If metals are more available to the biota, toxic effects are more likely to be seen. Sulfides will bind with cadmium, copper, lead, nickel, and zinc. These metal sulfide compounds will typically remain insoluble under reducing (anaerobic) conditions. This reduces the amount of toxic metals available to organisms, even under aerobic conditions. If the summed SEM-AVS is greater than zero, the toxic metals are more likely to be bioavailable since there is insufficient sulfide to completely bind them. Other substances, like organic compounds, can also bind these metals. Therefore, when SEM-AVS is greater than zero, the metals may still not be available. SEM-AVS was greater than zero in 10 of 12 samples (83 percent) in Area A-3 (Table 7-2). At the background location two of three samples (67 percent) had SEM-AVS values greater than zero. Therefore, the toxic, bivalent metals appear to be available in Area A-3, perhaps more available than in background areas; (page 38 in Appendix D indicates sampling locations).

For most of the metals, the extractable fraction is most of the total metal concentration (Table 7-2b). One exception is copper, which has very little of the total metal extracted with the AVS. Most of the copper in these sediments may be associated with organic matter.

7.1.3 Habitats and Potentially Exposed Receptor Groups

The majority of the study area has been disturbed by commercial and residential development (paving, building, dredging), this has impacted the wetland areas and associated habitats.

Some 53 species of fish and 11 invertebrate species are expected to use the Housatonic for spawning, adult forage, or as a nursery ground for juveniles (NOAA, 1998). Recreational fish and invertebrate species include Atlantic menhaden, black sea bass, bluefish, four species of flounder, American eel, striped bass, white perch, and the blue crab. The American eel and the eastern oyster are caught commercially in this area. An important commercial larval bed for eastern oyster cultivation in the Housatonic River is present near the mouth of Ferry Creek.

Little information is available on wildlife use of the area around Ferry Creek. Black-crowned night herons and red-winged blackbirds have been observed near Ferry Creek (NOAA, 1998) and geese, swans, and shore birds are common on the lower Housatonic River. Of all the native threatened or endangered species, the Atlantic sturgeon is likely to be found in the vicinity of Ferry Creek, and bald eagles and peregrine falcons may use the area while in transit.

7.2 Routes of Exposure

The ERA focused on the effect of chemical contamination on the ecological environment of the Area I study area from soil-waste/fill originating at the Raymark Facility. Extensive sampling has indicated the presence of Raymark-type soil-waste/fill within the Area I study area. This waste contains varying amounts of contaminants including asbestos, PCBs, copper, and lead.

Ecological receptors are exposed to contaminants through several routes. These pathways of contaminant movement and contaminant entry to ecological receptors are diagrammed on Figure 7-1. Aquatic organisms can take up toxicants directly from contact with water or sediment. Terrestrial organisms can also take up contaminants from direct contact with contaminated soil, water, and sediment. Animals can ingest contaminants with surface water, soil, or food. Inhalation and uptake through foliage are also potential routes of exposure for terrestrial life, but they were not considered in the NOAA ERA, which focused on aquatic pathways and receptors (NOAA, 1998).

7.3 Identification of Contaminants of Concern

Contaminants of Concern (COCs) were selected following review of chemical concentration data for surface water, sediment, and the tissues of aquatic organisms. Soil and groundwater data were not evaluated in the ERA prepared by NOAA. Selection of the COCs involved comparing measured concentrations of contaminants to screening values. Screening values were the effects range-low (ERL) concentrations in sediment (Long & Morgan, 1990). Dioxin and furan concentrations were expressed as TCDD TEQ concentrations and compared to a TCDD screening value for sediment. If no screening values were available, then a contaminant was included as a COC if it was detected in fish or shellfish tissue from historic samples.

The COCs are listed on Table 7-3, toxic effects are described in the NOAA ERA in Appendix D. Many of the COCs are PAHs; these are components of petroleum-based fuels and lubricants. Dioxins and furans are COCs; these are byproducts of the manufacture of, or the incomplete combustion of, chlorinated compounds such as PCBs. The COC list includes several metals, and metals were used in manufacturing processes at Raymark. Pesticides may have been used for pest control at the Raymark Facility.

7.4 Selection of Ecological Endpoints

Ecological endpoint refers to setting goals within the risk assessment and addressing how the goals will be met. Goals for the assessment, or assessment endpoints, are the protection of the indigenous benthic community (oysters, fish, birds, and mammals) that may be exposed to contaminants in the study area. The goals are met by taking measurements that relate to the assessment endpoints. To start, sediment contaminant concentrations were measured and compared to published concentrations representing acceptable risk to benthic communities. Sediment toxicity tests were performed and compared to background samples tested at the same time. Also, the benthic community in Ferry Creek was sampled, measured, and compared to communities at the background locations. Finally, contaminant levels in tissue were measured and used to estimate risks to animals that eat the tissue.

7.5 Selection of Indicator Species

Numerous species of aquatic invertebrates, fish, mammals, and birds could be exposed to the COCs within the study area. The selection of representative species for the study area was based on relevance to the assessment endpoints, life history, and ecological niche within the study area. The selected receptors are: benthic infauna, fiddler crab, American oyster, mummichog, red-winged blackbird, black-crowned night heron, and the raccoon.

7.6 Ecological Effects

This section discusses the potential adverse effects of contaminants on the indicator species, based on the measurements described above.

7.6.1 Chemistry

Measurement of chemical concentrations in surface water and sediment indicates the nature and extent of contamination. These measurements are used to estimate the potential for risk to ecological receptors. Risk is estimated by comparing surface water concentrations to ambient water quality criteria, and by comparing sediment concentrations to threshold effects levels.

Organic compounds and metals were measured in 14 surface water samples, and in 3 background samples. Only two organic COCs were detected at levels exceeding water quality criteria. The pesticide 4,4'-DDD was measured in a sample from Area A-1 at 0.026 μg/L, and Aroclor-1262 (a mixture of PCBs) was detected at 0.15 μg/L in one sample from Area A-3 (Table 7-4). For both of these analytes, the water quality criterion is based on food-chain effects, not direct toxicity to aquatic life. Secondary Chronic Values (SCVs) (ORNL, 1996) are protective of aquatic life; the SCVs for DDT and Aroclor-1262 are 0.013 and 94 μg/L, respectively. Therefore, only the single DDT concentration of 0.026 μg/L may be directly harmful. Food chain effects are discussed in Section 7.6.3.

Arsenic, chromium, lead, mercury, nickel, and zinc in surface water were at concentrations greater than at least one of their ambient water quality criteria. As shown on Table 7-4, the freshwater criteria for copper, lead, nickel, and zinc are hardness-based, and a 100 mg/L hardness was assumed. The mercury criteria are based on risks resulting from biomagnification of mercury in the food chain, they are not based on effects to aquatic organisms directly exposed to mercury in the water. The SCV for mercury is 1.3 μg/L (ORNL, 1996); only the highest site value, 1.7 μg/L, exceeded it. Also, mercury exceeded the lower criteria at two of the three reference locations, and one of these had the highest value measured, 6.0 µg/L. Potential risk exists when any ambient water quality criterion is exceeded, but "the only clear indication of risk is likely associated with the sample from SD13, due to the number and magnitude of exceedances" (NOAA, 1998). Sample location SD13 is in a swale draining eastward toward Ferry Creek in Area A-3 (page 10 in Appendix D includes sample locations).

Sediment contaminants were measured in a maximum of 61 samples (not every sample was analyzed for every contaminant) and 6 background samples. Threshold effect levels (MacDonald et al., 1996) were used as screening values for sediment concentrations. These are guidelines below which adverse biological effects are not expected to occur. Screening was performed by dividing the mean contaminant concentration for each area by the threshold effect level (TEL) (Table 7-5). The resulting hazard quotient (HQ_{TEL}), if less than one, suggests that adverse biological impacts are unlikely.

Except for arsenic, all of the sediment metal COCs had HQ_{TEL} values of one or greater (Table 7-5). Similarly, HQ_{TEL} values for the reference location were above one for all of the COC metals except arsenic (Silver was not detected.). Chromium and mercury HQ_{TEL} values were less than the corresponding HQ_{TEL} for the reference area. Copper and lead had the highest HQ_{TEL} values among the sediment metals. Relative to background, lead is more elevated than copper in the study area. Cadmium and silver have similar concentrations in the study area, which are elevated relative to background. HQ_{TEL} values for nickel and zinc were two to three times higher in Area A-3 than in Area A-1 and the background location.

As with copper, nickel, and zinc, sediment HQ_{TEL} values for organics were highest in Area A-3. Total PCBs had the highest HQ_{TEL} values overall with 125 at Area A-1 and 463 at Area A-3 (Table 7-5). The reference area had an HQ_{TEL} value of 1.3 for PCBs. HQ_{TEL} values for dioxins and furans were 32 in Area A-1 and 74 in Area A-3; the reference HQ_{TEL} was 1.3. Total PAHs had HQ_{TEL} values of 8.6, 11.p, and 16.0 for background, Area A-1 and Area A-3, respectively. HQ_{TEL} levels for DDT and its metabolites ranged from 0.3 to 3.1 in background, 2.6 to 8.1 in Area A-1, and 5.8 to 20.2 in Area A-3.

In summary, sediment screening results indicate potential risk from exposure to all of the COCs selected in the preliminary Ecological Risk Assessment (EVS, 1995). Relative to background, PCBs, dioxins, lead, copper, and pesticides appear to contribute most to potential risk.

7.6.2 Contaminant Residue in Organisms

Contaminant concentrations in tissue can be used to evaluate how much exposure to toxicants has occurred, the potential for harm to organisms containing the residue, and what exposures may result from consuming the tissue. Tissue from fish, fiddler crabs, and insects were analyzed. The results are summarized below.

Fish. Fish tissue was collected in 1995 (NOAA, 1998) and in 1997 (SAIC, 1998). The mummichog was selected as the subject for fish tissue analysis because of its nearshore benthic feeding habits and small home range. NOAA collected four whole-fish samples in both the study area and the Milford Point background location. SAIC collected two samples in the study area, and one in the Great Meadows background location.

Mummichog tissue had higher concentrations of cadmium, copper, lead, nickel, and PAHs (Table 7-6) than background. This indicates that these chemicals are available for uptake, and that exposure has occurred. Fish from the study area were analyzed only for PCBs and dioxins; the values were similar to background. To evaluate the potential effects of elevated concentrations on the mummichog, the concentrations were compared to guideline levels. Guidelines were available for cadmium, dioxins, and PAHs (NOAA, 1998). Two of four samples were above the cadmium and PAH guidelines in tissue, indicating potential risk to the mummichog. Potential risks to predators eating mummichog are discussed in Section 7.6.3.

Crabs. Fiddler crabs were analyzed for contaminant levels in order to estimate exposure to birds that feed on hermit crabs. Samples, consisting of at least 40 crabs, were collected from the study area and the background location at Milford Point. Elevated concentrations of cadmium, copper, lead, PCBs, dioxins, and PAHs were found in fiddler crab tissue (Table 7-7). Cadmium and PAH levels were about an order of magnitude higher (in Area A -3) than in the background.

Insects. Insects were collected to estimate exposure to birds that feed on insects. One composite sample was taken in the study area and one in the background location by sweeping vegetation with nets. Somewhat elevated concentrations of dioxins were seen in the study area relative to background (2.23 TCDD equivalents versus 1.38 TCDD equivalents).

7.6.3 Effects on Wildlife

Residue levels in prey were used to estimate effects on the raccoon and two bird species: black-crowned night heron and red-winged blackbird. Heron and raccoon were assumed to feed 100 percent of the time in each area, consuming fish, crabs, terrestrial insects, and incidentally, sediment (SAIC, 1999). Estimated doses from feeding and drinking water were summed and compared to threshold doses from the toxicological literature using the quotient method. The sums of mean hazard quotients for the black-crowned night heron were 3.82 for background, 4.70 in Area A-1, and 8.09 in Area A-3. Lead contributed about 50 percent of the risk in the study area, while DDT contributed most to the risk (48 percent) at the background location. The sums of mean hazard quotients for the raccoon were 1.94, 2.75, and 5.39 at the reference area, Area A-1, and Area A-3. Copper and lead contributed most to the raccoons risk. The summed quotients for both receptors indicate that the study area has more potential risk than the background area. The increase in risk over background is largely from the lead and copper in sediment that is assumed to be ingested incidentally. Lead concentrations in sediments in the study area, are very high relative to the background (Table 7-5). Copper levels in sediments are also higher than background. The modeled incidental sediment ingestion is conservative, and the assumption of 100 percent foraging in Ferry Creek may not be realistic for these animals. Although uncertainty is apparent, the heron and the raccoon are potentially at risk from COCs in the study area.

Red-winged blackbirds, unlike herons and raccoons, feed predominantly on insects. Potential risk to the blackbird was estimated from contaminant concentrations in terrestrial insects sampled from marshes. The greatest contributor to risk is zinc, at about 40 percent of the total. Because the estimated risk at the background location is greater than the risk in the study area, the risk to the blackbird from contaminants is negligible.

Red-winged blackbirds were assumed to consume insects 100 percent of the time from the study area. Comparison of estimated exposures to threshold doses indicated that blackbirds were not at any more risk in the study area than in the background location.

7.6.4 Toxicity Testing

Two investigations of sediment toxicity were conducted for areas associated with Raymark soil-waste/fill (NOAA, 1998 and in SAIC, 1998). Both investigations tested survival of amphipods and development of larval invertebrates.

7.6.4.1 NOAA Toxicity Investigation

The toxicity of sediment to the amphipod *Leptocheirus plumulosus* was evaluated by testing three samples from the study area and three samples from the background locations. One sample from each area was used for testing the toxicity of sediment to oyster larvae.

The amphipod test lasted 10 days and measured acute toxicity or survival. Survival was significantly lower than reference and control sediments for two samples from the study area (NOAA, 1998). Results indicated that surface water contaminants exceed water quality criteria; there are elevated PCBs, total PAHs, and dioxins in sediment; and there are high SEM-AVS values.

The sediment in the study area was also toxic to oyster larvae (NOAA, 1998). One sample had high concentrations of total PAHs, total PCBs, and dioxins at levels that were above background.

7.6.4.2 SAIC Toxicity Investigation

Sediment samples were evaluated to determine what type of chemical was causing toxicity. This was done by treating samples of pore water to remove organics, metals, ammonium, and sulfide, and then performing toxicity tests after each treatment. This study was done to develop preliminary remediation goals for the Feasibility Study. The SAIC investigation also analyzed whole sediment and untreated pore water for toxicity and chemical concentrations. These results are discussed below.

Sediment samples were taken from both the study area and the background area (SAIC, 1998). Whole-sediment testing with the amphipod *Ampelisca abdita* revealed survival ranging from 1 percent relative to the laboratory control sediment to 97 percent of the control. Results of the testing indicated the sediment was only moderately toxic.

Copper is considered a primary COC contributing to sediment toxicity. Arsenic, zinc, PCBs, and dioxins were also identified as potentially contributing to effects observed during testing.

7.6.5 Benthic Community Analysis

Four grab samples were collected from each of four stations for macroinvertebrate identification and counting (NOAA, 1998). The sampled stations included areas from the study area, one from a low salinity background location (Beaver Brook), and one from a high salinity background location (Milford Point). The analysis consisted of comparisons between reference and potentially impacted stations for total abundance, abundance in major taxonomic groups, and index values for species diversity, evenness, and richness. The results indicated that the area is clearly degraded relative to the low salinity reference location, with depressed abundance, richness, evenness, and diversity.

7.7 Summary and Conclusions

The ecological risk investigations assessed the risk to ecological receptors in the study area from Raymark soil-waste/fill. The results from these evaluations indicate;

- Mummichog tissue showed levels of exposure higher than the background area to cadmium, copper, lead, nickel, and PAHs. Tissue concentrations of cadmium and PAH indicate potential risk to mummichog.

- Concentrations of arsenic, chromium, lead, mercury, nickel, and zinc in surface water may be harmful to fish and other forms of aquatic life.

- Fiddler crab tissue show high levels of contamination of cadmium and PAH, indicating the availability of these sediment contaminants.

- Insects had somewhat elevated concentrations of dioxins, indicating dioxin bioavailability in the system.

- Sediments were toxic to amphipods in 9 of 11 tests, oyster larvae at the one location, and clam larvae in all eight laboratory tests. Toxicity in bulk sediments was associated with levels of PCBs, dioxins, PAHs, and a number of metals, including copper and lead.

- Copper was identified as the primary COC contributing to sediment toxicity via pore water exposure. Arsenic, zinc, PCBs, and dioxins were also identified as potentially contributing to effects.

- Potential risk exists for wildlife and mammals feeding in the aquatic environment from exposure to elevated concentrations of lead and copper in food and sediment. Fish-eating birds appear to be at elevated risk from exposure to lead. Comparison of estimated exposures to threshold doses indicated that birds feeding in the terrestrial environment were not at risk.

- The benthic macroinvertebrate community is degraded in the study area.

7.7.1 Uncertainties

A brief discussion of uncertainties associated with the ecological risk assessment details two general types of uncertainties: uncertainties related to measurements and those related to the availability of information. Measurement uncertainties include the adequacy of the study design, the variability due to sampling and analysis, and errors in data handling and reporting. For example, sampling variability associated with chemical concentration and macroinvertebrate community measurements in sediments tends to be high. There is also uncertainty associated with the co-occurrence of elevated contaminant concentrations and biological effects. Because many contaminants vary in concentration together, it is difficult to establish a cause-and-effect relationship for particular contaminants. Uncertainty due to the availability of information is often considerable. To save costs and time, surrogates for large groups of organisms are used for toxicity testing and estimating the effects of contaminants in the food web. Although the species used in toxicity tests are typically sensitive to toxicants, there is uncertainty in relating the sensitivity of test organisms under laboratory conditions to the larger community under natural conditions. The food web modeling for wildlife exposure and the subsequent estimation of toxic effects have many sources of uncertainty. These include the appropriateness of the surrogate selected for modeling, the assumptions made about feeding (including the fraction of ingested contaminants that are bioavailable), the potential for multiple contaminants to have synergistic or antagonistic effects, and the application of toxicity data from dissimilar species tested in laboratories.

8.0 SUMMARY AND CONCLUSIONS

The Area I study area consists of Ferry Creek, adjacent wetlands, and properties adjacent to these water bodies. It is located within the 100-year floodplain in the Housatonic River Basin, a tidally influenced system. The Area I study area covers approximately 28.8 acres, which includes 4.5 acres of wetlands and open water and encompasses commercial properties, and portions of residential properties. The Area I topography is moderately flat with gentle slopes to Ferry Creek and the Housatonic River.

This Final Area I RI report summarizes the activities performed under various investigation programs by federal, state, and private contractors. An enormous amount of data has been collected (Appendix B). Investigations have been performed by more than 30 entities over a 7-year period (1992-1999). Biota, surface water, groundwater, air, sediment, and soil samples have been taken. The media under discussion for this Area I study area include biota surface water, sediments, and soils. Groundwater was not included within the scope of this Area I RI, but is being addressed under a separate work assignment (W.A. No. 029-RICO-01H3). No air samples are included in this study because air samples were only taken for worker health and safety purposes.

The objectives of this Area I RI are to:

- Serve as the mechanism for compiling and evaluating all available data needed to characterize the Area I study area conditions,
- To determine the nature and extent of contamination in the surface water, sediment, and soil; and contaminant movement on Area I properties impacted by waste from the Raymark Facility,
- Assess the risks to human health and the ecological receptors within the study area and,

- Serve as the data resource for developing, screening, and evaluating a potential range of alternative remedial actions that address the contamination within the study area.

As detailed in Section 2.0, the Area I study area is located south of the former Raymark Facility. This area was targeted for study because waste from the Raymark Facility was disposed of on or near the properties. The Area I study area includes areas that are impacted by the Raymark waste through either direct disposal of soil-waste/fill or deposition of Raymark-related contaminants via surface water flow, storm runoff, or other means.

8.1 Nature and Extent of Contamination Summary

This section summarizes Section 4.0 of the RI by detailing the known nature and extent of the contamination.

8.1.1 Nature of the Contamination within Area I

The Raymark Facility type waste, referred to in this document as Raymark-type waste or Raymark soil-waste/fill, contains volatile and semi-volatile organic compounds (VOCs and SVOCs), pesticides, polychlorinated biphenyls (PCBs), dioxins and furans, metals (lead, copper, and barium), and asbestos. This Raymark-type waste was disposed of as fill material throughout the study area. Additionally, process water and runoff from the Raymark Facility containing these contaminants was directly discharged to Ferry Creek, which runs through Area I. Groundwater, soils, surface water, and sediments throughout the Area I study area have been contaminated from the Raymark Facility discharges, and from the properties that received Raymark waste as fill. The pattern of contamination within the study area indicates various disposal practices. The paragraphs below summarize the extent of contamination by medium and area. Areas and media not identified with frequent contamination can be assumed to have infrequent or non-existent contamination.

8.1.2 Extent of Contamination within Area I

The contamination in Area I is in the soils, surface water and sediments (groundwater is also contaminated but is not the focus of this RI). This contamination is the result of waste depositions as fill on properties in and around the Area I study area and from transport of waste directly from the facility or from these deposit areas.

The fill that was investigated in the Area I study area is a mixture of natural and man-made materials. Natural fill is made of clay, silt, sand, and gravel. Man-made materials consist of asphalt, metal, brick, glass, and other miscellaneous man-made materials, including manufacturing debris.

The extensive field investigations have revealed that contaminants of Raymark-type waste are present in soils, at both the surface and subsurface sediments, in the Ferry Creek channel, Housatonic River (to be discussed in more detail in the Area II RI) and adjacent wetlands, and in the surface waters of Ferry Creek.

8.1.3 Volatile Organic Compounds (VOCs)

VOCs are an identified contaminant within the Area I study area on all three Area properties (Areas A-1, A-2 and A-3).

8.1.3.1 Nature of VOC Contamination

Three primary groups of VOCs were detected within the study area: chlorinated hydrocarbons, aromatic hydrocarbons, and ketones. Many of these are commonly used in industrial processes; they are also constituents of gasoline and petroleum fuels.

8.1.3.2 Extent of VOC Contamination

- Area A-1 – No frequent detections in sediments or soils. Select VOCs, primarily chlorinated hydrocarbons, were detected frequently in the few surface water samples collected.

- Area A-2 – No sediment or surface water samples were taken in this area. No frequent detections in soils.

- Area A-3 – No frequent detections in sediments or soils. Select VOCs, primarily chlorinated hydrocarbons, were detected frequently in the few surface water samples collected.

8.1.4 Semivolatile Organic Compounds (SVOCs)

SVOCs are identified as a contaminant on all three properties within the Area I study area.

8.1.4.1 Nature of SVOC Contamination

Three primary groups of SVOCs were detected within the study area: phenolic compounds, polynuclear aromatic hydrocarbons (PAHs), and phthalates. Many of these are common constituents of various industrial products, used in the manufacture of friction materials (such as those made at Raymark), and are associated with fuels, coal, and petroleum products. Phthalates were used as plasticizers in the manufacture of synthetic products (such as the synthetic resins made at Raymark).

8.1.4.2 Extent of SVOC Contamination

- Area A-1 - SVOCs were frequently detected in both surficial and subsurface sediments and soils. No frequent detections in surface waters.

- Area A-2 – No sediment or surface water samples were taken in this area. SVOCs were frequently detected in both surface and subsurface soils.

- Area A-3 – SVOCs were frequently detected in surficial sediments, surficial soils, and subsurface soils. No frequent detections in subsurface sediments. SVOCs were not detected in surface water.

8.1.5 Pesticides

Pesticides are an identified contaminant on all three properties within the Area I study area.

8.1.5.1 Nature of Pesticide Contamination

Pesticides are assumed to have been used at the Raymark Facility, as indicated by pest control practices common in manufacturing plants. Pesticides were detected in residential soil-waste stored at the Raymark Facility

8.1.5.2 Extent of Pesticide Contamination

- Area A-1 - Pesticides were frequently detected in surficial and subsurface sediments and soils. No frequent detections in surface waters.

- Area A-2 – No sediment or surface water samples were collected from Area A-2. Pesticides were frequently detected in surficial and subsurface soils.

- Area A-3 – Pesticides were frequently detected in surficial sediment samples, surficial soils, and subsurface soils. No frequent detections in subsurface sediment and surface waters.

8.1.6 Polychlorinated Biphenyls (PCBs)

PCBs are an identified contaminant on all three properties within the Area I study area.

8.1.6.1 Nature of PCB Contamination

The PCBs identified within the study area consisted primarily of Aroclor 1262 and Aroclor 1268. PCBs are typically used as plasticizers in the manufacture of brake linings, rubber gaskets, and synthetic resins (such as were made at Raymark).

8.1.6.2 Extent of PCB Contamination

- Area A-1 – PCBs were frequently detected in both surficial and subsurface sediments and soils. No PCB detections were in surface waters.

- Area A-2 – PCBs were frequently detected in both surficial and subsurface soils. No surface water or sediment samples were taken in this area.

- Area A-3 – PCBs were frequently detected in surficial sediments, surficial soils, and subsurface soils. No frequent PCB detections in subsurface sediments. No PCB detections were in surface waters.

8.1.7 Dioxins/Furans

Dioxin/furans are an identified contaminant on all properties within the Area I study area.

8.1.7.1 Nature of Dioxin/furan Contamination

Dioxins/furans are not used in manufacturing processes; they are formed during the production of chlorinated compounds (such as pesticides or PCBs) or from incomplete combustion of chlorinated compounds.

8.1.7.2 Extent of Dioxin/furan Contamination

- Area A-1 – Dioxins/furans were frequently detected in surficial sediment samples, surficial soils, and subsurface soils. No frequent detections in subsurface sediment samples. No surface water samples were analyzed for dioxins/furans in Area I.

- Area A-2 – Dioxins/furans were frequently detected in surficial and subsurface soil samples. No sediment samples were taken in Area A-2. No surface water samples were analyzed for dioxins/furans in Area I.

- Area A-3 – Dioxins/furans were frequently detected in surficial sediment samples, surficial soils, and subsurface soils. No frequent detections in subsurface sediment samples. No surface water samples were analyzed for dioxins/furans in Area I.

8.1.8 Metals

Metals are an identified contaminant on all three properties within the Area I study area.

8.1.8.1 Nature of Metals Contamination

The most prevalent elevated Raymark-related metals detected within the study area were copper and lead. These metals are used in fabricating brake and friction products (such as were used at Raymark). These metals within the study area appear to originate from Raymark waste, from the facility and filled areas, and from transport and deposition of the wastes from these locations.

8.1.8.2 Extent of Metals Contamination

- Area A-1 – Metals were frequently detected in surficial and subsurface sediments (copper and lead), surficial and subsurface soils (copper and lead), and in surface waters (antimony, arsenic, iron, barium, manganese, and zinc).

- Area A-2 – Metals were frequently detected in surficial and subsurface soils (copper and lead). No sediment or surface water samples were collected from this area.

- Area A-3 – Metals were frequently detected in surficial and subsurface sediment (copper and lead), surficial and subsurface soil samples (copper and lead) and in surface waters (chromium, barium, manganese, zinc, mercury, aluminum, copper, and lead).

8.1.9 Asbestos

Asbestos is an identified contaminant on all three properties within the Area I study area.

8.1.9.1 Nature of Asbestos Contamination

Asbestos-containing materials were a primary component of products manufactured at the Raymark Facility. Asbestos fibers were mixed with phenolic resins to manufacture brake pads, linings, clutches, transmission plates, and gaskets.

8.1.9.2 Extent of Asbestos Contamination

- Area A-1 – Asbestos was frequently detected at greater than one percent in both surficial and subsurface sediments and soils. No surface water samples were analyzed for asbestos.

- Area A-2 – Asbestos was frequently detected in surficial and subsurface soils. No sediment or surface water samples were collected in Area A-2.

- Area A-3 – Asbestos was frequently detected in surficial sediment, surficial soils, and subsurface soils. No frequent detections of asbestos in subsurface sediment. No surface water samples were analyzed for asbestos.

8.2 Contaminant Fate and Transport Summary

Contaminant fate and transport in the environment are controlled by a number of factors: chemical and physical properties of the contaminants, geologic formations, hydrologic conditions, aquifer conductivity, topography, precipitation, and tidal flow.

The contaminants identified in the nature and extent discussion are associated with the former Raymark Facility. Major pathways of migration within the Area I study area were wastewater and drainage discharge, erosion from the Raymark Facility to Ferry Creek, and runoff from the Raymark-type soil-waste/fill areas into Ferry Creek, and then to the Housatonic River. Water flowing through this area (both naturally and tidally) also eroded the Ferry Creek bank where Raymark-type soil-waste/fill had been disposed of on properties bordering the creek.

Wastewater and drainage discharge from the Raymark Facility principally contributed to contamination in Ferry Creek sediment and surface water. The discharges ceased when the Raymark Facility closed in 1989. The placement of the contaminated waste as fill on properties within the Area I study area is the predominant source of soil contamination across Area I and is a continuing source of contamination to sediments and surface waters. The placement of the contaminated waste has resulted in the direct and indirect release of contamination into the surface water, sediments, and soils within the study area.

8.3 Risk Assessment Summary

The risk assessment for this RI focused on both human health and ecological risks.

8.3.1 Human Health Risk Assessment

The Human Health Risk Assessment identified total PAHs; total PCBs; metals-copper, lead, and barium; dioxin/furans; and asbestos as the primary contaminants of concern within the study area. These contaminants were selected based on their toxicity, occurrence within the study area, and existence at the Raymark Facility. See Table 8-1 for a summary of the potential risks that could result from exposure to Raymark soil-waste.

8.3.1.1 Area A-1

In Area A-1, the following risks are identified;

- Carcinogenic risks have been identified for the adolescent trespasser (CTDEP target risk only), commercial worker, and the combined adult and child frequent recreational user of the area. The contaminants placing these people at risk are PAHs (benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene), PCBs, dioxins/furans, and arsenic in surficial soils. Carcinogenic risks have been identified for future commercial workers exposed to soils to a depth of 15 feet bgs from dioxins/furans, total Aroclors, arsenic, and PAHs (benzo(a)pyrene, benzo(b)fluoranthene, and dibenzo(a,h)anthracene). No carcinogenic risks have been identified for exposures to surface water.

- Noncarcinogenic risks are not anticipated for receptors in Area A-1.

- Potential risks from exposure to lead in soil have been identified for the recreational child, and current and future commercial workers. Further evaluation of lead "hot spots" indicates that exposures to lead in more limited locations would result in blood lead levels of significantly greater concern, especially to children (including fetuses).

- Asbestos in Area A-1 poses a potential inhalation risk when migrating through the air. No quantitative risk estimates are available.

8.3.1.2 Area A-2

In Area A-2, the following risks have been identified:

- Carcinogenic risks have been identified for the commercial worker. The contaminants placing that group at risk are PAHs, (benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene), PCBs, and dioxins/furans in surface and subsurface soils.

- Noncarcinogenic risks are not anticipated for any receptor in Area A-2.

- Potential risks from exposure to lead in soils have been identified for the commercial worker. Further evaluation of lead "hot spots" indicates that exposures to lead in more limited locations would result in blood lead levels of significantly greater concern, especially for children (including fetuses).

- Asbestos in Area A-2 soil poses an inhalation risk when migrating through the air. No qualitative risk estimates are available.

8.3.1.3 Area A-3

In Area A-3, the following risks have been identified;

- Non-carcinogenic risks are not anticipated for receptors in Area A-2.

- Carcinogenic risks have been identified for the combined adult and child frequent recreational user of the area. The contaminants placing those groups at risk are benzo(a)pyrene, dibenzo(a)anthracene, benzo(b)fluoranthene, dibenzo(a,h) anthracene, dioxins/furans, PCB, and arsenic in soils and sediments. Surface water risk drivers are PCBs, arsenic, vinyl chloride, and 1,1-dichloroethene.

- Potential risks from exposure to lead in soils have been identified for the adult and child frequent recreational users of the area in surface soils and surface sediments.

- Asbestos in Area A-3 soil poses an inhalation risk when migrating through the air. No qualitative risk estimates are available.

8.3.2 Ecological Risk Evaluation

The Ecological Risk Assessment was conducted by NOAA; SAIC conducted a supplemental ecological investigation and analysis. TtNUS has summarized their assessments in Section 7.0, the full text of these documents are in Appendix D. To facilitate understanding of the results, see Table 8-1 for a summary of the potential risks that could result from exposure to Raymark-type waste.

8.3.2.1 Area A-1

In Area A-1 the following risks are identified:

- Mummichogs showed high exposure levels of cadmium, copper, lead, nickel, and PAHs in their tissues; cadmium and PAH are potential risk drivers to the mummichog.

- Surface water concentrations of arsenic, chromium, lead, mercury, nickel, and zinc may be harmful to aquatic life.

- Fiddler crabs showed high levels of cadmium and PAH contamination, indicating the availability of these contaminants in the sediments.

- Insects showed elevated concentrations of dioxins, indicating the availability of dioxin in the system.

- Mammals feeding in the aquatic environment will be at risk for exposure to lead and copper. This risk extends to fish-eating birds, especially for lead risks.

8.3.2.2 <u>Area A-2</u>

No ecological receptors are present in this area.

8.3.2.3 <u>Area A-3</u>

In Area A-3 the following risks are identified;

- Mummichogs showed high exposure levels of cadmium, copper, lead, nickel, and PAHs in their tissues; cadmium and PAH are potential risk drivers to the mummichog

- Sediments were toxic to amphipods, oyster larvae, and clam larvae. Toxicity is associated with PCBs, dioxins, PAHs, copper, lead, zinc and arsenic.

- Fiddler crabs showed high levels of cadmium and PAH contamination, indicating the availability of these contaminants in the sediments.

- Insects showed elevated concentrations of dioxins, indicating the availability of dioxin in the system.

- Mammals feeding in the aquatic environment will be at risk for exposure to lead and copper. This risk extends to fish-eating birds, especially for lead risks.

8.4 Conclusions

The interpretation of the data and information compiled for this RI indicates that;

- Raymark Facility-type soil-waste/fill was disposed of as fill throughout the study area.
- Fill and natural soils throughout the study area are contaminated with asbestos, lead, copper, SVOCs, PCBs, and dioxins. In some areas, the level of contamination is high.
- Analysis of soil, sediment, and surface water samples reveals that there is widespread contamination of the soil and sediments with limited surface water contamination. Although contamination is ubiquitous, the contaminants and concentrations are not distributed evenly across the study area (because of irregular dumping patterns).
- Potential risk to human health from Raymark-type waste is of concern throughout the study area.
- Toxicity risks exist for sediment-dwelling organisms, and those that are up the food chain, that use the ecological areas of the study area for home or food.

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